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Experiments into the operation and effectiveness of Edge Organizations

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Experiments into the operation and effectiveness of Edge Organizations

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Abstract

Over the past year a team from QinetiQ in the UK has been investigating Edge Organizations under the sponsorship of the CCRP[1]. The aim of the work was to establish the command arrangements for Edge Organizations, showing how these arrangements will work in many types of operational environment and how they perform against traditional, hierarchical organizations with more centralized command styles and against extremely decentralized organizations.

The working premise was that the command arrangements of an Edge Organization can only be fully understood within the operational context. Hence how an organization operates can only be understood in the full context of its environment. The study first considered and characterized the environment, then the Edge Organization within it and finally the necessary command arrangements that enable the Edge Organization to operate. The study concluded that an experimental campaign was required to test the thesis:

> *"…the organizational agility of Edge Organizations allows their operating units to exert more decisive influence over a wider range of adversarial organizations within many types of operational contexts than those of less agile centralized or de-centralized organizations."*

The aim of the second part of the study is to explore the thesis above by simulating combat operations between organisations with different command arrangements (including the extremes) and then measuring and assessing the benefits of adapting organisational form and function. Initially, war games with military experts were used to determine characteristics of command arrangements and to identify the parameters of the competing organisations that were then used as the inputs into a combat simulation (QinetiQ's HiLOCA model). The results presented in this paper are preliminary and form only the first part of an experimental programme. This preliminary simulation study has helped to provide a set of recommendations for development of models and metrics that will be capable of carrying out a full set of experiments to investigate organisational agility through command and control (C2) agility within a range of operational settings.
The overall aim is to carry out a further set of experiments to investigate the ways in which an Edge Organisation would re-configure itself such that decisive influences emerge that would give it advantage over a wide range of adversarial organisations and

[1] This work has been carried out under funding from **OASD-NII**

would allow it to co-operate with organisations of differing maturity and form (e.g. NGOs). The final analyses will aim to provide a formalised organisational agility landscape, a set of policy rules to define required degrees of freedom and a set of necessary re-configuration mechanisms for an Edge Organisation with associated costs and benefits (in design, build and operational terms) of composing and maintaining such Edge Organisations.

Introduction

As part of the CCRP, QinetiQ has been tasked with examining the Command and Control (C2) arrangements for Edge Organizations. The intention is to model various command and control arrangements, including a tentative arrangement for Edge Organizations, in a limited number of operational settings in order to see how their performances compare. Once this analysis has been conducted it is intended that high fidelity modeling will be done to fine-tune the C2 arrangements for Edge Organizations. A multi-phase approach conducting this research has been adopted, as shown in Figure 1.

The first phase investigated the concept of an Edge Organization in enough detail for modeling to take place. This investigation was based upon the premise that the C2 arrangements cannot be understood until the form and desired behavior of the host organization is known, and that this form and behavior cannot be understood without knowing what the operating environment is like. This phase of the work is summarized in the next section of this paper.

The second phase characterization the C2 arrangements for Edge Organization in such a way that they can be modeled within our in-house agent-based combat model, HiLOCA; the intention being to see if the C2 characteristics that we have identified produce emergent behaviors that we expect from an Edge Organization. This “proof-of-concept” modeling will be done in a realistic combat environment against a variety of types of adversarial organizations. This will be described in the third section of this paper and results will be presented at the symposium.

The third phase is planned to be undertaken as an experimental campaign in which a C2 arrangement for Edge Organization will be refined within a full set of operational contexts and against a larger variety of different adversaries. It is expected that our in-house model, HiLOCA, will not be able to model all aspects Edge Organizations that we would like. Hence the first part of this phase will be an investigation into other, complementary, models that can be used together to meet the requirements of the Experimental Campaign. This future phase of the work is not reported here.

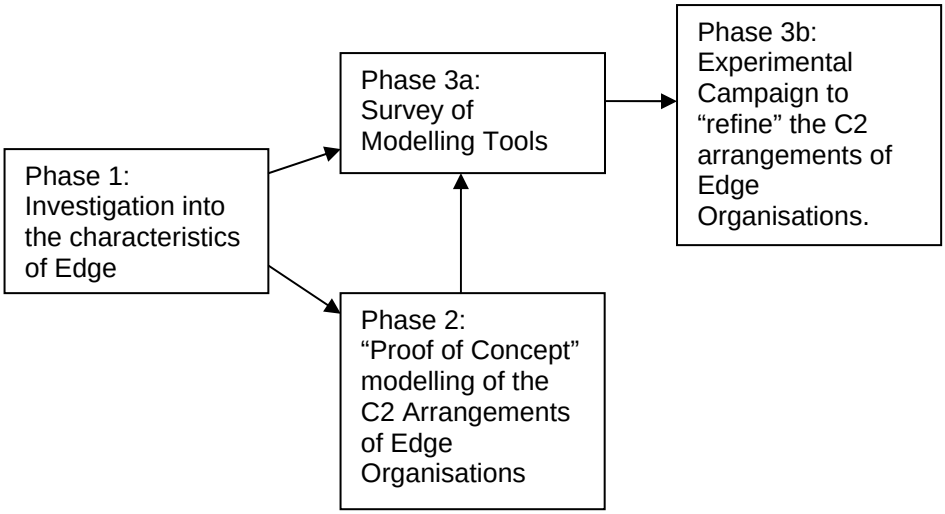

Figure 1: The approach to understanding the C2 Arrangements of Edge Organizations.

Review of Phase 1: The Characteristics of Edge Organizations.

The future environment that the military will find itself in is likely to be radically different from the one of the not too distant past. Rather than fighting a single enemy in open warfare the future military will be operating in an environment within which there are many adversaries, friends, neutrals and allies all mixed and difficult to tell apart; where allegiances are constantly changing and where conflicts will be conflicts of wills and not means. This constantly changing and ill-defined environment will be one that defies such detailed analyses as was possible during the Cold War, when own actions could realistically be planned to counter those of a well-rehearsed adversary.

To exist, thrive and win in this type fast changing, unpredictable environment, the military organization needs to be agile. Alberts and Hayes [1] define six aspects of agility as in Table 1 below.

Robustness	The ability to maintain effectiveness across a range of tasks, situation, and conditions.
Resilience	The ability to recover from or adjust to misfortune, damage, or a destabilizing perturbation in the environment.
Responsiveness	The ability to react to a change in the environment in a timely manner.
Flexibility	The ability to employ multiple ways to succeed and the capacity to move seamlessly between them.
Innovation	The ability to do new things and the ability to do old things in new ways.
Adaptation	The ability to change work processes and the ability to change the organization.

Table 1: The six characteristics of Agility.

So what does an organization that exhibits these characteristics look like?

- It must be able to sense the environment and itself and postulate futures.
- It must be able to react to local situations as they develop, but in a manner that is consistent with organizational purpose or intent.

- It must be able to form itself into new structures, to adapt to new situations, responsively, reactively or proactively.
- It must have a strong sense of “organizational” identity whilst having local accountability.
- It must be able to form its own perception of other agencies value systems and how postulated futures would impact them.
- It must be able to make decisions wherever and whenever necessary, whilst keeping within overall organizational intent.
- It must have a balance between “generalist” units that can be brought to bear on a range of tasks and “specialist” units that are needed to undertake high-skill tasks.
- It has a well understood organizational level “success measure” that local “success measures” need to be measured against.
- It is a learning system, capable of adaptation.

If these characteristics are compared with those of a Complex Adaptive System (CAS) then there is a very high degree of similarity, see Grisogono [2]. From this characterization of the Edge Organization we derived a conceptual organizational model that concentrates on command and control from which we could derive a set of generic C2 command arrangements. The model is shown in Figure 2 below.

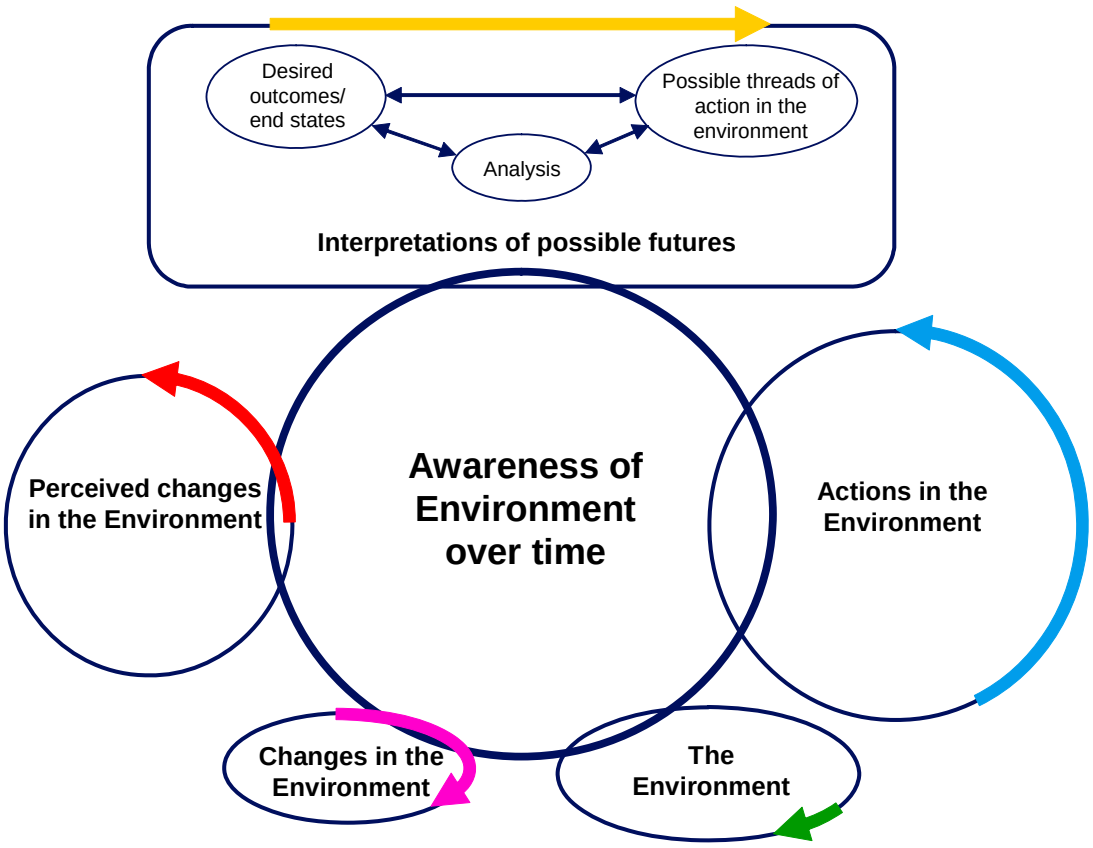

Figure 2: A Conceptual Model for an Organization.

The model is built around an organization having a continually evolving awareness of the environment over time and its own place (and that of others) in it. The awareness over time changes as the organization *perceives* real changes in the environment. This can only ever be a perception as the organization’s sensors are not perfect nor are they comprehensive and the cognitive element of the organization can never fully “understand”

all that it sees. As awareness of the environment builds up it enables interpretations of possible futures to be constructed, as an extended analysis of where the organization thinks it is now (awareness of the environment), from a statement of desired outcome or expected (or worst possible) end-states and the feasible threads of actions and activities from now that could lead to these outcomes. One of these threads must be chosen to be acted upon and thus results in actions in the environment that the deciding unit in the organization hopes or believes will bring about the desired outcome.

The structure of the conceptual model as shown is very important. There is no “process-loop” as there is no ordered progression through the elements of the model; all elements are undertaken concurrently. The size, color and direction of the arrows is an attempt to indicate that all elements within the model have their own natural cycles or rhythms and that it is the organization’s Awareness of the Environment over time that is the link between all the elements and is the mechanism for making sense of all the asynchronous activities.

If the comparison between how we have defined an agile organization (and hence our definition of an Edge Organization) and that of a CAS produces is such a close match then the implication is that the current tools we have for modeling military organizations and for simulating combat are not adequate. This conclusion has lead us to considering what sort of modeling environment we need to enable analysis of Edge Organizations in realistic, future operating environments against a range of adversarial organizations.

In order to derive the modeling requirements, a set of attributes have been generated. The tables below show suggested lists of attributes that we believe can be used not only to characterize Edge Organizations but also to characterize a large range of organizational types ranging from those that have a command style that is top-down (with no initiative afforded to active operating units) to ones that are characterized as a 'cell-based' decentralized organization with a widely-dispersed and diffused sense of identity and emergent sense of purpose.

Organizational Attributes
Identity and sense of self
Generation, maintenance and dissemination of purpose
Groupings of operating units
Decision-making [Delegation of decision rights]
Sense making [Shared awareness of non-self]
Sense making [Perception of environment and changes]
Status monitoring and decision-making [Shared Awareness of self, including status and setting resource priorities]
Synergy [Shared awareness of self and own operation with respect to others]
Success measures

Table 2: Organizational Attributes

Organizational Building Blocks
Infrastructures and support (including logistics and interactions)
Personnel
Training

Doctrine (expression of)
Doctrine (use of)
Equipments

Table 3: Organizational Building Blocks

Environmental Context
Organization's own values and concerns about impact of its actions
Organization's perception of how others assess impact of its actions
Physical environment
Rates of Change
Target Specification
Terrain
Complexity of the Environment
Prior models of others' behavior modes, patterns
Boundaries (legal, tactical and operational)
Resources
Predictability

Table 4: Environmental Context

Phase 2: Proof of concept modeling of C2 arrangements for Edge Organizations.

This phase of the work involves using the output of the first phase and taking lessons drawn from the war-game sessions so that the organizational characterizations can be parameterized to enable us to run some "proof of concept" combat simulations.

The aim of the preliminary "proof of concept" simulations is to investigate operational effects and define appropriate operational and organizational metrics whilst varying the nature of the C2 arrangements of two adversarial forces in combat. This work uses the 'Alberts-grid' as a reference framework [1] for defining the parameterization of information and intent sharing. Box 1 represents a baseline case for C2 and information sharing and Box 5 represents improved (network-enabled) processes. Box 1 and Box 5 parameters used in the model are similar to those derived for previous studies [3,4].
This study has also required us to parameterize the command structure in terms of the ways in which support units are deployed and employed across the force.

The key to parameterization of C2 arrangements is to capture both the constraints (in terms of the composition of a unit's organic assets) and the restraints (in terms of the ways in which the units can be re-allocated across the force). The lines of authority and lines of responsibility must be explicit in the force structures. The degree to which command intent must be adhered to by any unit is a key parameter.

The preliminary "proof of concept" simulations will only address force-on-force combat, albeit between extremely different types of organizations, as outlined in Table 5 below.

		DEFENDER		
AGGRESSOR		Top-down	Mission Command	De-layered
	Top-down Hierarchy	Y		Y
	Mission Command	Y		Y
	De-layered	Y		

Table 5: C2 arrangements in proof of concept combat simulations

The simulation used within this proof of concept study is QinetiQ's HiLOCA model [5]. HiLOCA is an object-oriented stochastic combat simulation that is able to model aspects of C2 and information sharing with a degree of fidelity that is sufficient for a proof of concept study. A schematic representation of the four functions and associated messaging routes is shown in the figure below.

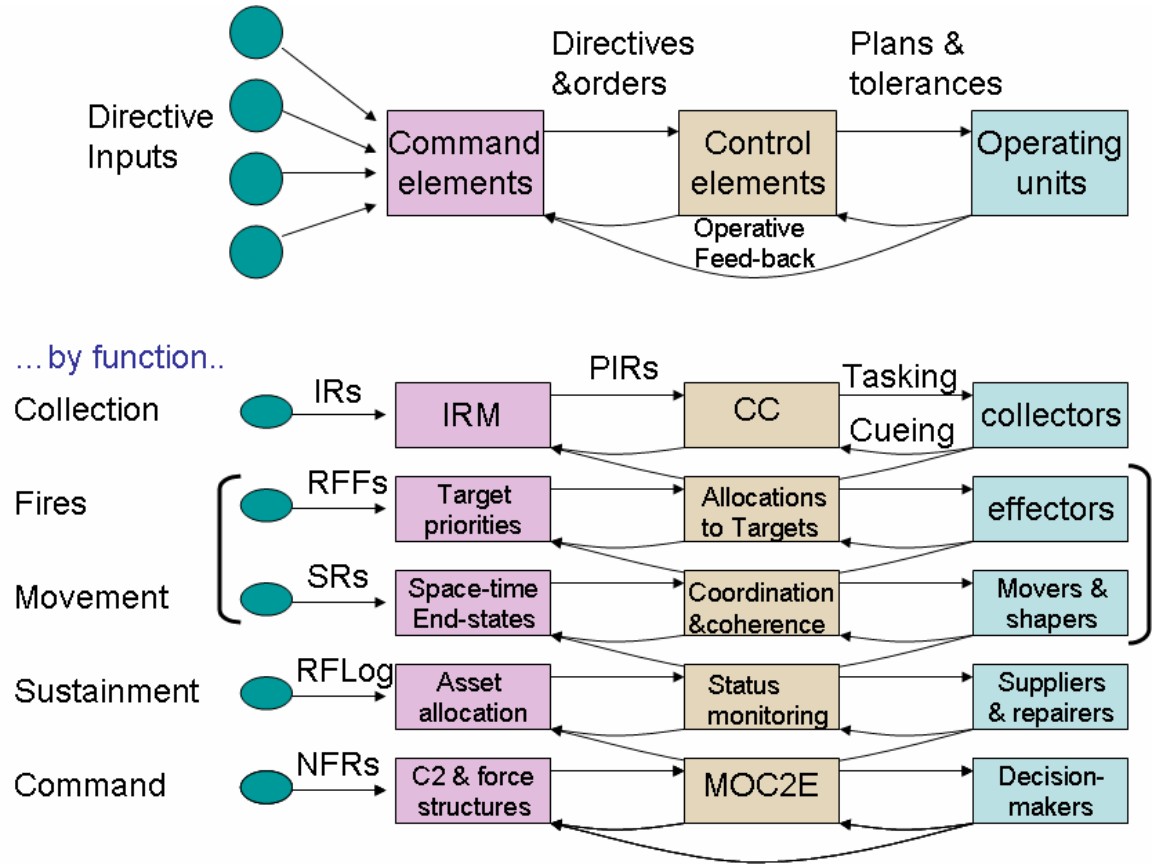

Figure 3: Specification of Feedback and Feed forward between a Network of Interacting Elements.

The key point is to understand that there are messages across each of the four functions that relate to command (feed-forward information about intent, constraints and restraints) and that relate to control (feed-back information about operational status and requests for support and Intelligence). Essentially the parameterization falls into three “informational” areas: command, control and execution.

HiLOCA is configured with two different libraries corresponding to the two combinations of parameters representing a combat force operating within Box 1 or Box 5. For each of the C2-arrangements/Alberts-grid combinations we run several HiLOCA replications and two main categories of operational effectiveness metrics are recorded: -

- Details on casualties taken over time of both defender and aggressor.
- Measures of operational tempo.

Results of this preliminary investigation (into the impact of differing C2 arrangements on operational effectiveness within the context of a UK-based vignette) will be presented showing changes in operational tempo due to adapted C2 processes and Information sharing.

References

1 “Power To The Edge”, David S Alberts, Richard E Hayes, CCRP Information Age Transformation series, June 2003, ISBN 1-893723-13-5

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3 “NEC and ‘Knowledge of Own Forces’ Quantifying the Impact on Operational Effectiveness”, S B Richardson, L Dodd, March 2005.

4 “Using the HiLOCA model to support Future HQ structures study and future NEC analysis”, L Dodd & S B Richardson, March 2004, QINETIQ/KI/INTSYS/WP040899.

5 "HiLOCA Library user guide", D E Skinner and P R Nicholas, QINETIQ/KI/ISR/ITR/UG/03

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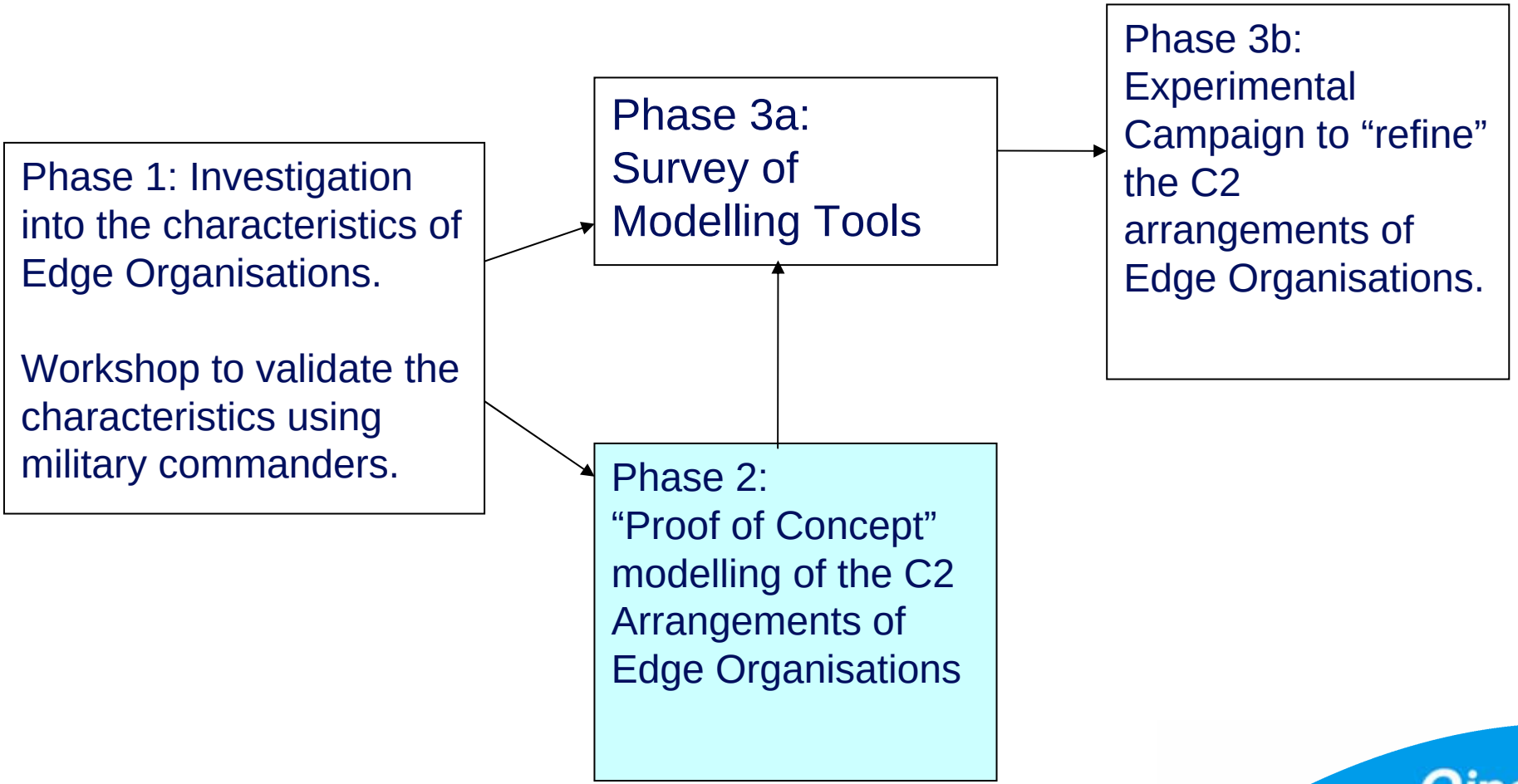
C2 Experimentation track
CCRTS San Diego
20-22 June 2006

QinetiQ

Overall programme of work (Part of CCRP)
CCRTS paper covers Phase 1 and Phase 2 only



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Proof of concept simulations

- Full experimentation will address the thesis:

"…the organizational agility of Edge Organizations allows their operating units to exert more decisive influence over a wider range of adversarial organizations within many types of operational contexts than those of less agile centralized or de-centralized organizations."

- Initial step will only simulate combat operations between organizations
  - with different force structures;
  - varying command freedoms;
  - and structural flexibility.

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Characterisations fall into three areas

- Operational Environment
  - The context in which the operation is set (including political, geographical, adversarial, economic, etc)
- Organisational building blocks
  - The materiel, infrastructures, personnel, doctrine, etc
- Organisational attributes
  - The structural linkages (interactions, interdependencies)

This will be fixed

These will be fixed

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Proof of concept simulations

	Operational Environment	Building Blocks	Organisational Attributes
Simulation run 1	Fixed	Fixed	Attacking force: Top down Defending force: Mission Command
Simulation run 2	Fixed	Fixed	Attacking force: Mission Command Defending force: Mission Command
Simulation run 3	Fixed	Fixed	Attacking force: Delayered Defending force: Mission Command

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Operational environment

Organization’s own values and concerns about impact of its actions
Organization’s perception of how others assess impact of its actions
Physical environment (weather, day/night, ease of movement, etc)
Rates of Change (of events that are particularly representative)
Target Specification (general “signal-to-noise” issues)
Terrain (e.g. urban, mountainous, flat)
Complexity of the Environment (nature and spread of knock-on interactions)
Prior models of others’ behavior modes, patterns (familiarity, “knowns”)
Boundaries (legal, tactical and operational) and their nature (fixed or flexible)
Resources (criticality of assets and ability to share)
Predictability (relates to familiarity, consistency, etc)

FIXED

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Organizational Building Blocks

Infrastructures and supporting structures
Personnel (natural restraints on activity/motivation)
Training (specific skill sets)
Doctrine (expression of)
Doctrine (use of)
Equipments

FIXED

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Organizational Attributes

Identity and sense of self
Generation, maintenance and dissemination of purpose
Groupings of operating units
Decision-making [Delegation of decision rights]
Sense making [Shared awareness of non-self]
Sense making [Perception of environment and changes]
Status monitoring and decision-making [Shared Awareness of self, including status and setting resource priorities]
Synergy [Shared awareness of self and own operation with respect to others]
Success measures

Focus of the simulations

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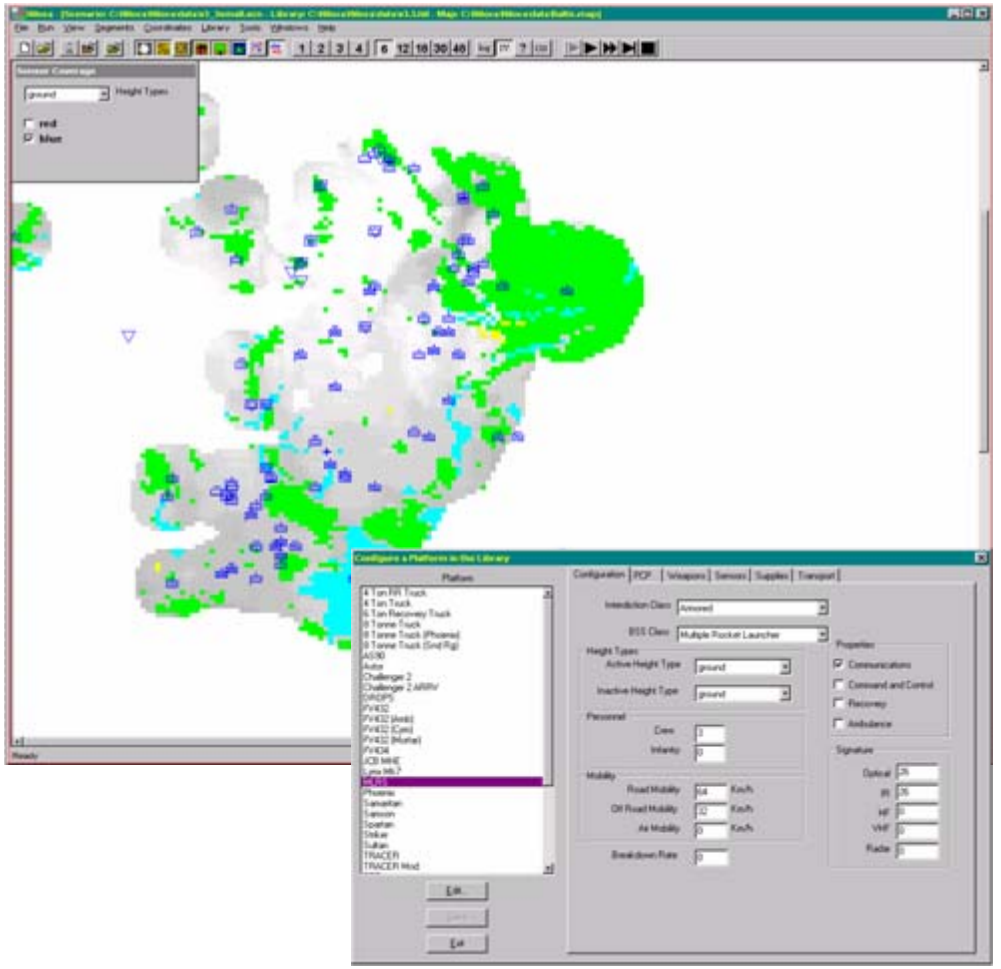
HiLOCA: High Level Operations model using Command Agents & Cellular Automata



- Dynamic analysis of C2I2 operational effectiveness
- Explicit representation of C2I2 structures, interactions and HQ functions
- User-configured building blocks for concept development
- System-of-systems studies

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HiLOCA outputs

- High level combat effectiveness measures such as casualties, force tempo and losses.
- Logistics usage and deficits
- Picture compilation metrics
- Command decisions and timings
- Sensor reports and sensor movements
- Own force status messages
- Own force movements – all units over time

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Independent variables for the simulations

- Force (ORBAT) structure (responsibility & “ownership”)
- Assignment of support units (e.g. re-allocation of artillery)
- Command freedoms (adherence to superior’s intent)
- Alberts’ grid Box 4 and Box 5 parameters
  - Own force information sharing
  - Forward movement & planning horizons
- Logistics C2 structures (demand-led or supply-determined)
- ISTAR architectures (distribution of sensor-derived info)

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Independent variables for the simulations

	Force Structure (Command Layers)	Assignment of support Units	Command Freedoms
Top down (A1)	4	None	Low
Mission command (A2)	3	Long range artillery	Medium
Delayered (A3)	2	Long range artillery, Manoeuvre Units, AH	High

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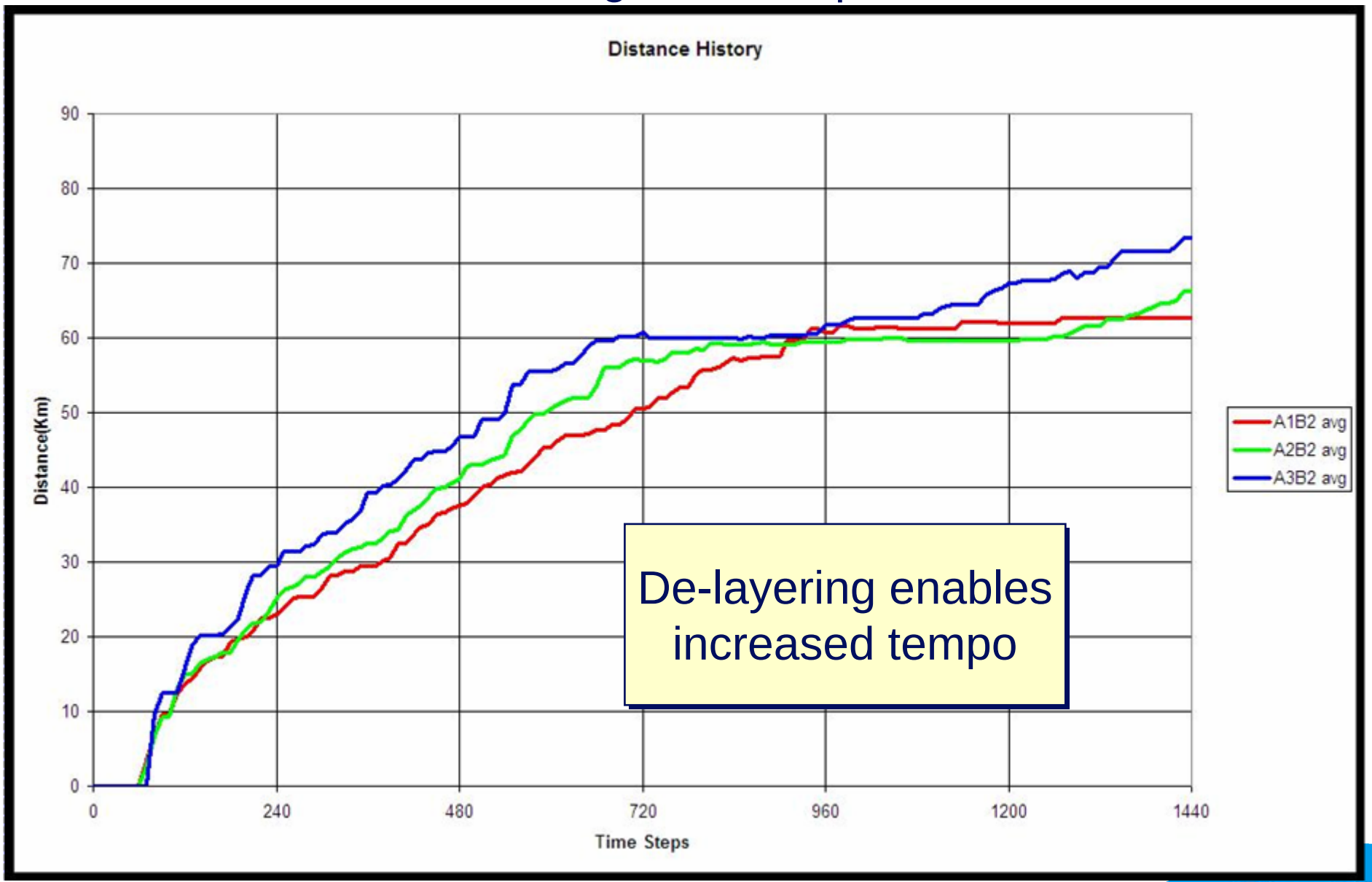
Attacking force tempo



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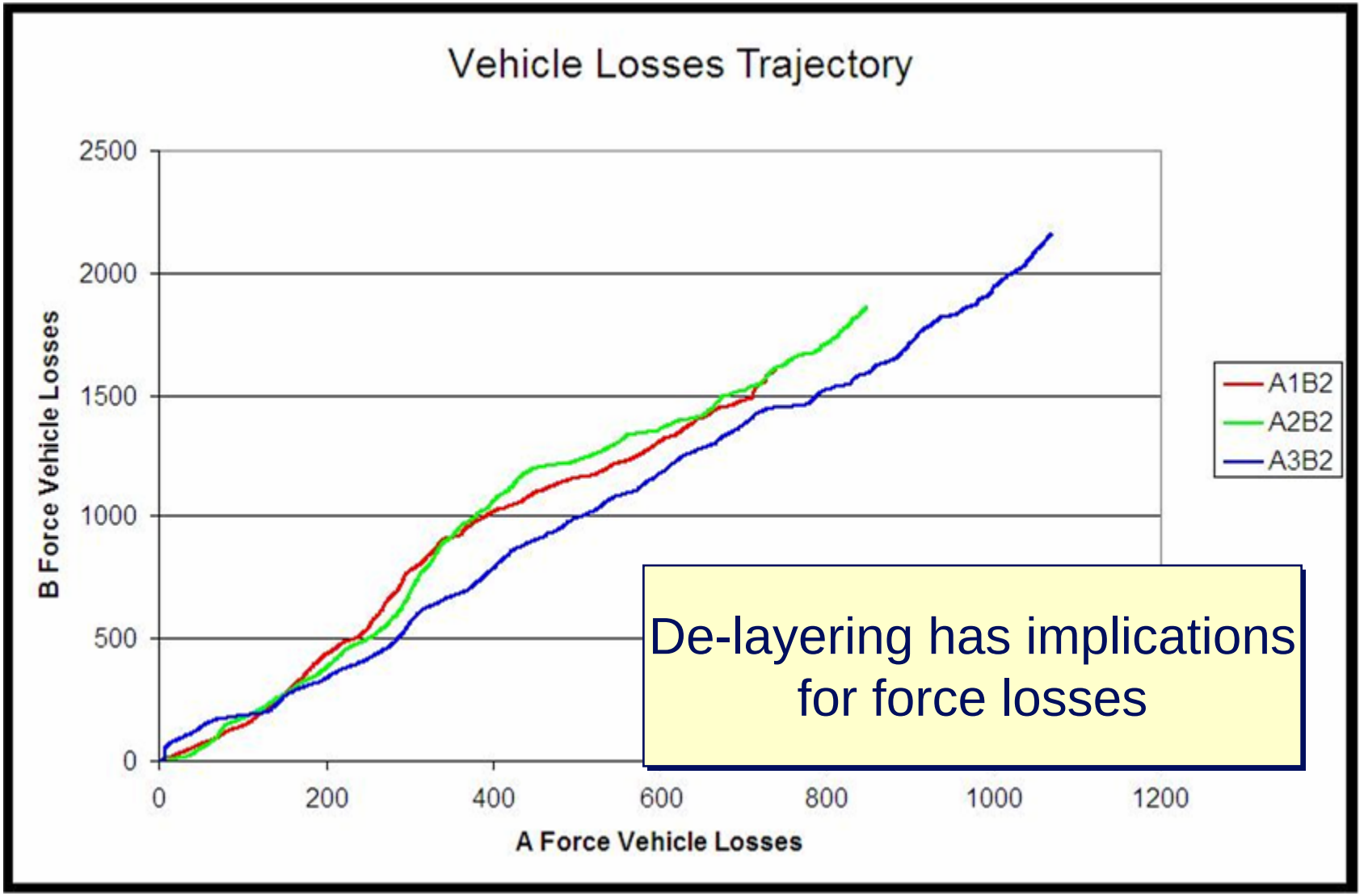

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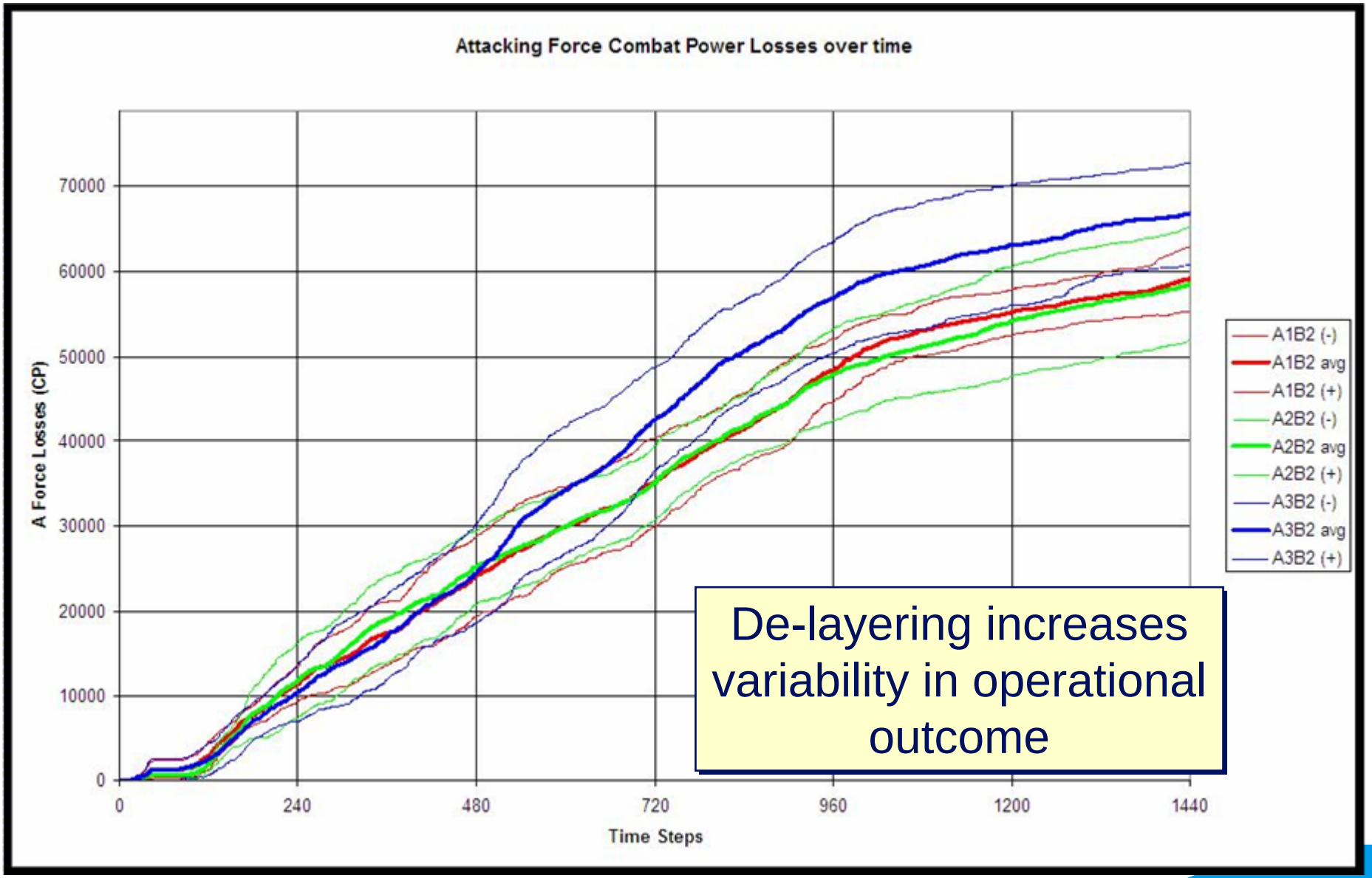

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Summary

- We have presented:
  - A taxonomy for characterising organisations.
  - An initial mapping across from the organisational attributes to the HiLOCA combat model.
  - Preliminary indications of operational effectiveness of de-layering against a fixed adversarial environment.
- We propose for future experimental phase:
  - an extended agent-based approach for structural adaptation through C2 characterisation space;
  - using focussed intervention vignettes to cover more of the C2 problem space.

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